2 March 1973

Type I Progress Report for the Period 14 December 1972 to 14 February 1973 for ERTS-1 Data User Investigation of the Use of ERTS Imagery in Reservoir Management and Operation - Proposal Number MMC 89

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The fourth 2-month period of our participation in the ERTS-1 program has been featured by:

a. A small increase in the size of our DCS network, with installation progress being temporarily slowed by winter weather conditions.

b. Continued collection and entry into our computer of all DCS and ground truth data.

c. Continued study and evaluation of the ability of ERTS imagery pictures to provide hydrologically useful information.

d. Study and developmental work in the reprocessing of bulk-processed images to enhance those features which will be useful from a watershed management viewpoint.

e. Continued progress in the development and refinement of computer-oriented image processing and analysis techniques.

A listing of the locations of our operating DCP's and proposed sites is inclosed. Note changes from the list submitted with our last report. To date we have noticed no significant adverse effects of winter weather conditions upon DCP performance. The "Gel-Cell" batteries are continuing to provide excellent service. Reduction of the data that we have already received is proceeding smoothly. We anticipate that by early spring we should have a sufficient data bank to begin some preliminary statistical analyses.

Our imagery studies continue to be divided between the ERTS pictures and the magnetic tape products.

Several methods of image reprocessing are being studied with the aim of enhancing contrasts of water bodies and hydrologic properties which appear ambiguous in NASA bulk-processed products. One of the major problems we are experiencing with NASA imagery is that of too much scene darkness (rather than scene brightness as described in ERTS Investigators Bulletin No. 13). Better interpretation of hydrologic features appears to be facilitated by processing images at higher film densities, especially in the near IR band.

A great deal of time was devoted during the reporting period to our continuing computer-oriented imagery work. IBM 360 computer printouts of RBV-3 magnetic tapes of ERTS image E-1006-15063 have been produced and are being studied (see section 3.3 of our June-December 1972 report). Experiments with these printouts include production of computer maps with variations of spatial and tonal-level resolution. Printouts can be made with as many as 16 different levels of response in alphanumeric symbols corresponding to the 16 different levels of the "gray-scale". When properly color-coded, maps show more information than photo-products. Because hand coloring is required, which demands considerable manual effort, this method is feasible for only selected areas and features. Computer printout maps can be made with a wide range of spatial scales. For example, the largest "magnification" occurs when there is a one to one correspondence between resolution elements on the magnetic tape and those reproduced on the standard IBM printout sheet (about 190 x the spatial scale on a 9.5 x 9.5 inch photo, or about 1:5,260). Wide area coverage would require several printout sheets, however smaller area analysis of selected features can be "blown-up" to fit the full size of the IBM printout sheet.

Experimentation with varying special resolutions and tonal resolutions is continuing. For example, image 1006-15063 in its first quadrant shows a part of the Hudson River. This part was first tried for color technique. After assigning 16 colors for each level of gray in the hexadecimal range and 5 colors for each level in the visual range, a comparison of the colored computer maps with the original photo image was made. It was observed

that the computer maps show many details not noticeable in the images. By virtue of its 16-level representation, the hexadecimal output has more information than the 5-level visual representation. However, more detailed interpretation of each level is still underway.

It was also observed that the interference of cloud or haze shows a different tonal level for the same object. For example, the Hudson River (using a 5-level tonal system) appeared "orange" under a haze condition but "blue" under clear air conditions. (A later paragraph describes a computer-man interactive program which is aimed at solving such problems). Using the RBV-3 frame we are beginning the study of the Connecticut River, Quabbin Reservoir, Coventry Lake and the Hartford region - all in southern New England.

MSS magnetic tapes of selected scenes (Merrimack River basin, snow scenes, etc.) will be ordered and printouts of these also will be produced, based on modification of the computer program to permit the handling of the MSS data. MSS magnetic tapes to be ordered are as follows:

ID Number	Image Date
1077-15005	8 Oct 1972
1096-15065	27 Oct 1972
1132-15071	2 Dec 1972
1096-15063	27 Oct 1972
1132-15065	2 Dec 1972

Work has started on an interactive program for image processing designed to take advantage of the experience and training of people involved in the project, as well as the computational abilities of the computer, with the entire system involving two stages. First, a user works at a CRT (cathode ray tube) which displays sections of the image to be investigated at any spectral band. The user has the capabilities of moving the image, changing sections, or getting "closeups" on the screen. He then uses a light pen to roughly outline hydrologic features of interest, and inputs, through a keyboard, the name and conditions associated with the feature, e.g. "Quabbin Reservoir, 95% full, flood danger, raining." Next, the computer extracts information from all the spectral bands of the feature and stores it together with the input

ground truth on a computer tape. When sufficient information has been gathered over several images (each 18 days apart), the second stage begins. A new image will be presented and pattern recognition techniques will be used to combine all available information and predict (say) how full the Quabbin Reservoir is now and whether or not there is any flood danger.

One of the most important phases of the program will be an efficient means of storing information ascertained about the image. Current techniques will be sufficient for ground truth fed in by the user, but new means will be needed to extract "features" directly from the high masses of data with which we will be dealing. Without an interactive environment, these means, when developed for computers alone, are likely to be inefficient and very time-consuming. However, based on the user's outlines, locations of features with respect to latitude and longitude (using tick marks) can be isolated exactly. The computer is then asked to carry out finer and more detailed analysis which the user is unable to do efficiently.

The UConn Computer Center has a display system (2250) that is interfaced to the central computer IBM 360/65. Efforts are being made to look into the possibility of using such a facility for implementing the interactive system described above.

During the reporting period, no changes were made in our ERTS standing order forms. A special order for magnetic tapes will be made soon, as indicated in a previous paragraph.

1 Incl
As stated

SAUL COOPER
Principal Investigator

ERTS-1 - DCP INFORMATION SHEET
ARMY CORPS OF ENGINEERS, NEW ENGLAND DIVISION 28 FEB, 1973

ID NO.	DCP NO.	TYPE	STATION NAME	LAT	LONG	IN-STALLED
1	6170	S	ST. JOHN RIVER AT FORT KENT, MAINE	47 15	68 35	091972
2	6071	S	PENOBSCOT RIVER AT WEST ENFIELD, MAINE	45 14	68 39	092072
3	6021	S	CARABASSETT RIVER AT NORTH ANSON, MAINE	44 52	69 57	100472
4	6304	S	ANDROSCOGGIN RIVER AT AUBURN, MAINE	44 04	70 12	112772
5	6106	S	SACO RIVER AT CORNISH, MAINE	43 48	70 47	112872
6	6206	S	PEMIGEWASSET RIVER AT PLYMOUTH, N.H.	43 45	71 41	112272
7		S	MERRIMACK RIVER AT GOFFS FALLS, N.H.	42 57	71 28	
8		S	SOUHEGAN RIVER AT MERRIMACK, N.H.	42 51	71 31	
9	6356	S	CHARLES R. AT CHARLES R. VILLAGE, MASS.	42 15	71 15	071772
10	6220	S	TOWN BROOK AT QUINCY, MASS.	42 15	71 00	090872
11	6010	S	PAWTUXET RIVER AT CRANSTON, R.I.	41 45	71 27	090672
12	6127	S	CONNECTICUT RIVER AT HARTFORD, CONN.	41 46	72 40	083072
20		P	STINSON MOUNTAIN, N.H.	43 50	71 47	
21	6345	P	SOUTH MOUNTAIN, N.H.	42 59	71 35	120672
22		P	FRANKLIN FALLS DAM, N.H.	43 28	71 40	
23		P	BLACKWATER DAM, N.H.	43 19	71 44	
24		P	MACDOWELL DAM, N.H.	42 54	71 59	
25		P	MANSFIELD HOLLOW DAM, CONNECTICUT	41 46	72 11	
30	6101	C	STAMFORD BARRIER, STAMFORD, CONNECTICUT	41 02	73 32	011073
40	6254	Q	ASHUELOT RIVER AT WINCHESTER, N.H.	42 47	72 23	121272
41	6142	QS	NORTH NASHUA RIVER AT FITCHBURG, MASS.	42 34	71 47	110672
42	6355	Q	WESTFIELD R. AT WEST SPRINGFIELD, MASS.	42 06	72 38	092872
43	6242	Q	CHICOPEE RIVER AT CHICOPEE, MASS.	42 09	72 35	121472
50	6147	T	NED HEADQUARTERS, WALTHAM, MASS.	42 24	71 13	071772
51	6325	T	COLD REGIONS LAB AT HANOVER, N.H.	VARIABLE		
52	6216	T	COLD REGIONS LAB AT HANOVER, N.H.	VARIABLE		120572
53	6335	T	UNIV. OF CONN. AT STORRS, CONN.	VARIABLE		

* S-RIVER STAGE
P-PRECIPITATION
C-COASTAL(WIND DIRECTION,VELOCITY AND TIDE)
Q-WATER QUALITY(TEMPERATURE,CONDUCTIVITY,PH AND DISSOLVED OXYGEN)
T-TEST SET(SENSORS VARIABLE)